BRAZILIAN JOURNAL OF OCEANOGRAPHY, 62(2):149-164, 2014

SPATIAL AND TEMPORAL DISTRIBUTION PATTERNS OF LARVAL SCIAENIDS IN THE ESTUARINE SYSTEM AND ADJACENT CONTINENTAL SHELF OFF SANTOS, SOUTHEASTERN BRAZIL

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http://dx.doi.org/10.1590/S1679-87592014067606202

ABSTRACT

Based on data collected during the project "The influence of the Santos-São Vicente estuarine system on the ecosystem of the adjacent continental shelf" (ECOSAN), from Nov/2004 to Mar/2006, the space-temporal distribution pattern of Sciaenidae larvae in relation to biotic and abiotic factors was investigated. Bongo net was used for sampling, aboard the R/V "Prof. W. Besnard" on the shelf, and the boats "Veliger II" and "Albacora" in the estuarine region. Twelve taxa were identified: *Bairdiella ronchus, Ctenosciaena gracilicirrhus, Cynoscion spp., Isopisthus parvipinnis, Macrodon atricauda, Micropogonias furnieri, Menticirrhus spp., Nebris microps, Ophioscion punctatissimus, Paralonchurus brasiliensis, Stellifer rastrifer* and *Stellifer spp.* Sciaenidae larvae were widespread on the continental shelf in both campaigns (frequency of occurrence >80%). They were most abundant in Mar/2006 (mean = 6.47 larvae.m^{-2}; sd = 8.36) and least abundant in Sep/2005 (mean = 2.37 larvae.m^{-2}; sd = 3.33). The average abundance in the estuarine region ranged from 0.12 larvae.m^{-2} (sd = 0.11) in Jun/2005 to 4.28 larvae.m^{-2} (sd = 1.99) in Nov/2004. Frequency of occurrence minimum occurred in Aug/2005 (50%) and the maximum in Nov/2004 (100%). The presence of Sciaenidae larvae in most locations and periods suggests that the reproductive process of this family in the region is continuous, spawning being more intense in the warmer months.

RESUMO

Baseando-se em dados coletados durante o projeto "A Influência do Complexo Estuarino da Baixada Santista sobre o Ecossistema da Plataforma Continental Adjacente" (ECOSAN), nov/2004 - mar/2006, foram investigados os padrões de distribuição espaço-temporal das larvas de Sciaenidae relacionando-os com fatores bióticos e abióticos. A rede bongô foi utilizada como amostrador do ictioplâncton, a bordo de três embarcações: o N/Oc "Prof. W. Besnard" na plataforma, e os barcos "Veliger II" e "Albacora" na baía e canais. Doze táxons foram identificados: *Bairdiella ronchus, Ctenosciaena gracilicirrhus, Cynoscion spp., Isopisthus parvipinnis, Macrodon atricauda, Micropogonias furnieri, Menticirrhus spp., Nebris microps, Ophioscion punctatissimus, Paralonchurus brasiliensis, Stellifer rastrifer* and *Stellifer spp.* Na plataforma continental as larvas de cienídeos tiveram ampla distribuição nas duas campanhas (frequência de ocorrência > 80%), sendo mais abundantes em mar/2006 (6,47±8,36 larvas.m^{-2}) e menos abundantes em set/2005 (2,37±3,33 larvas.m^{-2}). No estuário, a abundância média das larvas de cienídeos variou entre 0,12±0,11 larvas.m^{-2} (jun/2005) e 4,28±1,99 larvas.m^{-2} (nov/2004); a frequência de ocorrência foi mínima em ago/2005 (50%) e máxima em nov/2004 (100%). A presença das larvas na maioria das estações de coleta do sistema estuarino de Santos e plataforma continental adjacente sugere uma atividade reprodutiva contínua, com desova mais intensa nos meses mais quentes.

Descriptors: Sciaenidae, Ichthyoplankton, Abundance, Environmental variables.
Descritores: Sciaenidae, Ictioplâncton, Abundância, Variáveis ambientais.

INTRODUCTION

Sciaenidae is a large family of about 70 genera and 270 species. They inhabit marine, brackish, and freshwater areas of the Atlantic, Indian, and Pacific oceans (NELSON, 2006). Most of the species of this family are classified as demersal fish, but some may feed in the pelagic environment. At least 54 species of Sciaenidae have been described on the Brazilian coast (CASATTI; MENEZES, 2003), some of them being important fishery resources. On the inner shelf of South and Southeastern Brazil the species *Micropogonias furnieri* (Desmarest, 1823), *Macrodon atricauda* (Günther, 1880), *Cynoscion guatucupa* (Cuvier, 1830), *Cynoscion jamaicensis* (Vaillant & Bocourt, 1883), and *Menticirrhus americanus* (Linnaeus, 1758) are among those most exploited by commercial fisheries (VALENTINI; PEZZUTO, 2006).

Many fishery resources, including some sciaenids, spawn in the ocean and the early stages are transported to estuaries, where the larvae may find a suitable environment for their survival and growth (GODEFROID et al., 1999; COSTA; ARAÚJO, 2003).

Larval fish usually are planktonic and they are in general morphologically very distinct from the corresponding adults. The transformation takes place gradually until they settle down in the adult environment. The knowledge of this process is important in enabling us to understand the population dynamics of fishes, as the size of adult stocks depends directly on their success in surviving during the early developmental stages (HANNA, 1998). The distribution of larval fish is heterogeneous and can vary in time and space, depending mainly on the fishes' reproductive strategies, including the place, time and type of spawning, adult abundance, the duration of the early stages, larval behavior and the presence of potential predators and prey, among other factors (NORCROSS; SHAW, 1984; LEIS, 1991; SASSA et al., 2004). The larval distribution is also influenced by climate and hydrographic events such as currents, winds, vortexes and the upwelling and stratification of the water column (DENMAN; POWELL, 1984; NORCROSS; SHAW, 1984).

Although the coastal area of the present study is known to be heavily impacted by human activities such as industrialization, port activities and urbanization (CETESB, 2001), the bay and the estuary in the Santos region interact with each other and form an environment recognized as an important nursery area for fish, crustaceans and molluscs (SCHAEFFER-NOVELLI; CINTRON, 1986). High diversity and abundance of fish have been observed in this region (PAIVA FILHO et al., 1987) and the sciaenids have been described as one of most important groups (PAIVA FILHO; SCHMIEGELOW, 1986). In the Santos Bay, Schmidt and Dias (2012) sampled 21 species of Sciaenidae, with *Stellifer rastrifer* (Jordan, 1889) representing 70.4% of the total composition.

Previous studies on the early life history of the sciaenids off Southern and Southeastern Brazil include those by Matsuura and Nakatani (1979) who described the development of larval *Umbrina coroides* Cuvier, 1830 near Anchieta island; Sinque (1980) who studied the larval and juvenile development of *Cynoscion leiarchus* (Cuvier, 1830), *Menticirrhus americanus*, *Micropogonias furnieri*, *Stellifer rastrifer*, *Macrodon ancylodon* (Bloch & Schneider, 1801) and *Isopisthus parvipinnis* (Cuvier, 1830) in the Cananéia-Iguape estuary; Katsuragawa et al. (1993) who described the larval distribution of *Menticirrhus americanus* at Ubatuba; Godefroid et al. (2001) who described the larval and juvenile occurrence of *Menticirrhus americanus*, *Menticirrhus littoralis* (Holbrook, 1847), *Umbrina coroides* and *Micropogonias furnieri* in the Pontal do Sul region; Bruno and Muelbert (2002; 2009) who investigated the distribution and abundance patterns of eggs and larvae of *Micropogonias furnieri* in the Patos lagoon, and Itagaki et al. (2007) who described the larval and juvenile development of *Bairdiella ronchus* (Cuvier, 1830) in the Cananéia-Iguape estuary. However, no studies on early sciaenids have been undertaken in the estuarine and coastal area around Santos.

Therefore, the present work analyzed the spatial and temporal distribution patterns of the Sciaenidae larvae and evaluated the influence of abiotic and biotic factors in the Santos estuarine system and on the adjacent continental shelf. We also discuss the importance of the study area to early life stages of some Sciaenidae species.

Material and Methods

Study Area and Sampling Techniques

The Baixada Santista, located on the central coast of São Paulo state - Brazil, covers the São Vicente and Santos estuarine system, the Santos Bay and the adjacent Continental Shelf (CETESB, 2001). The Santos Bay has a fundamental role in the dilution of materials from the channels of Santos and São Vicente, including those from the submarine emissary (PIRES-VANIN *et al.,* 2008). The Bertioga channel is an environment whose margins are better preserved than those of the Santos and São Vicente channels, even though the first is subject to habitat destruction as a result of urban occupation and the pollution that reaches its shores (PIRES-VANIN *et al.,* 2008). The adjacent continental shelf is complex, due its proximity to the coastal region and a greater number of variables involved in the oceanographic structure of the region. Variations in water temperature and salinity in this environment demonstrate the influence of different water masses throughout the year: Tropical Water (TW), Coastal Water (CW) and South

Atlantic Central Water (SACW) (MIRANDA; KATSURAGAWA, 1991; CASTRO et al., 2006).

Samples were collected during research cruises of the project "The influence of the Santos-São Vicente estuarine system on the ecosystem of the adjacent continental shelf" (ECOSAN), by the Oceanographic Institute of São Paulo University (IOUSP). In three localities in the Santos - São Vicente estuarine system (Santos Bay, Port Channel and Bertioga Channel) the cruises were conducted monthly at 12 oceanographic stations from November 2004 to March 2006; on the adjacent continental shelf (North and South areas) out to the 50 m isobath sampling plan included 37 and 36 oceanographic stations, respectively in September/2005 and March/2006 (Fig. 1). Oceanographic cruises were carried out by the R/V "Prof. W. Besnard" on the continental shelf, and the boats "Veliger II" and "Albacora" in the bay and channels. Summary information of each sampling station is presented in Tables 1 and 2.

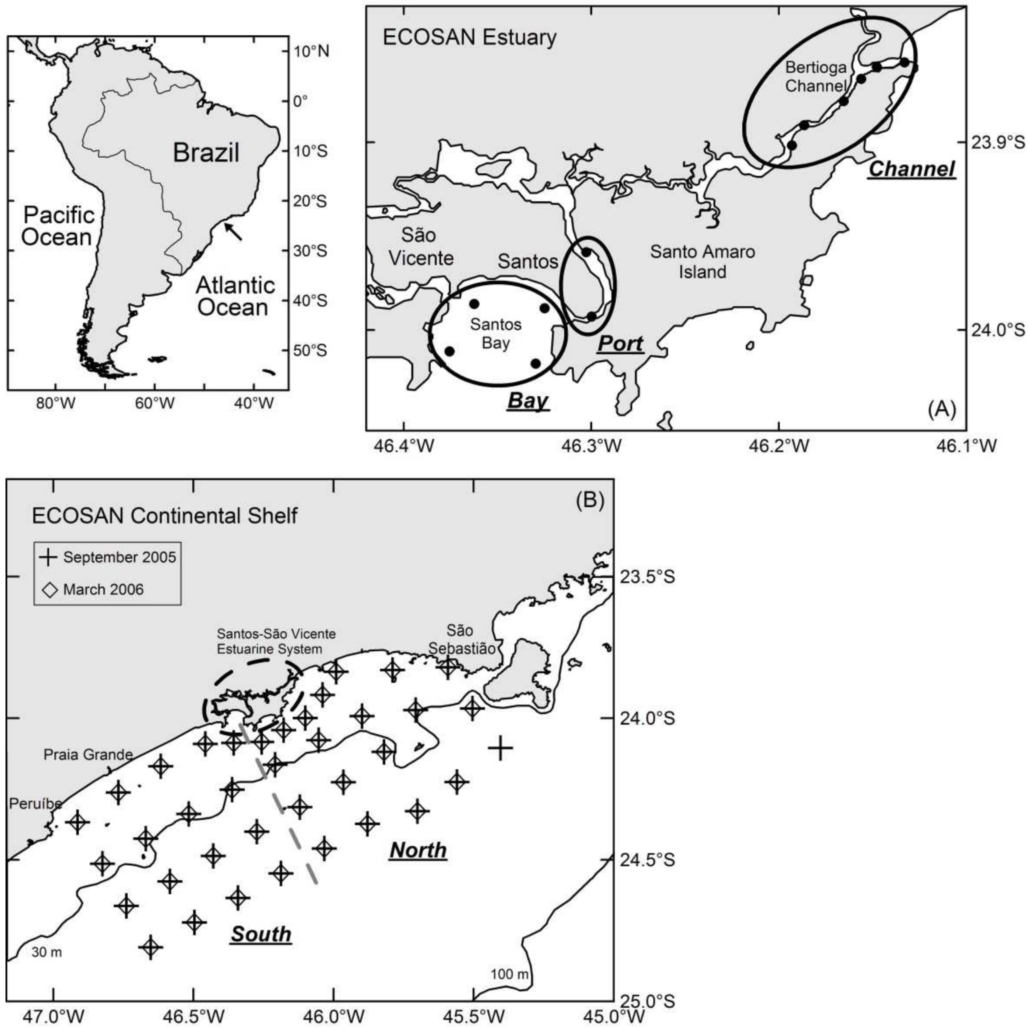

Fig. 1. Location of the sampling stations in the Santos estuarine system (Santos Bay, Port and Bertioga Channel) from November 2004 to December 2005 (A) and on the continental shelf between Peruíbe and south of São Sebastião island in September 2005 and March 2006 (B).

Table 1. Data of sampling stations carried out in Santos bay, Bertioga channel and Port channel in Santos-São Vicente estuarine system, Brazil, from November 2004 to December 2005 (LD - Local Depth (m); SD - Sampler Depth (m); T – Temperature; S - Salinity obtained at maximum depth of 5 m).

Santos bay

Date	Hour	Long.	Lat.	LD	SD	T*	S*	Date	Hour	Long.	Lat.	LD	SD	T*	S*
11/24/2004	11:58	-46.376	-24.011	10.4	9.0	22.96	35.59	5/21/2005	07:50	-46.330	-24.018	12.8	9.0	25.3	34.56
11/24/2004	11:23	-46.362	-23.986	7.6	6.0	22.24	35.72	5/21/2005	11:06	-46.325	-23.988	7.6	3.5	25.16	34.86
11/24/2004	13:14	-46.330	-24.018	13.4	12.0	22.26	35.25	6/24/2005	10:09	-46.376	-24.011	8.5	7.0	23.41	34.08
11/24/2004	10:14	-46.325	-23.988	6.9	5.0	22.04	35.72	6/24/2005	10:53	-46.362	-23.986	6.0	5.0	23.04	32.63
12/17/2004	13:19	-46.375	-24.011	11.0	9.0	24.03	35.43	6/24/2005	07:22	-46.330	-24.018	12.2	11.0	23.05	32.44
12/17/2004	10:07	-46.363	-23.988	7.9	6.0	24.74	34.84	6/24/2005	12:52	-46.325	-23.988	5.8	4.5	23.55	34.04
12/17/2004	14:45	-46.329	-24.016	13.0	11.5	24.79	34.20	7/23/2005	10:17	-46.376	-24.011	8.5	7.0	21.75	34.51
12/17/2004	09:27	-46.325	-23.989	7.0	4.5	24.84	33.16	7/23/2005	11:27	-46.362	-23.986	6.0	4.5	21.7	34.46
1/25/2005	11:03	-46.375	-24.011	10.5	8.0	25.43	34.00	7/23/2005	07:32	-46.330	-24.018	12.5	11.5	21.63	34.45
1/25/2005	12:15	-46.363	-23.988	7.6	5.0	24.77	34.94	7/23/2005	12:35	-46.325	-23.988	5.5	4.5	21.64	34.56
1/25/2005	09:29	-46.329	-24.016	12.0	9.0	25.33	34.34	8/20/2005	09:35	-46.376	-24.011	8.5	7.5	21.81	33.86
1/25/2005	12:48	-46.325	-23.989	7.3	4.5	25.04	34.51	8/20/2005	08:30	-46.362	-23.986	6.0	5.0	21.8	33.91
2/24/2005	13:04	-46.376	-24.011	11.0	9.0	25.25	34.31	8/20/2005	11:30	-46.330	-24.018	12.0	11.0	21.77	33.79
2/24/2005	12:09	-46.362	-23.986	7.6	5.5	25.61	34.03	8/20/2005	12:55	-46.325	-23.988	6.0	5.0	21.69	33.84
2/24/2005	14:25	-46.330	-24.018	13.7	11.0	26.27	34.17	10/1/2005	09:22	-46.376	-24.011	10.0	10.0	20.38	32.59
2/24/2005	07:44	-46.325	-23.988	6.4	4.5	25.59	33.54	10/1/2005	10:40	-46.362	-23.986	7.0	7.0	20.28	32.73
3/22/2005	13:20	-46.376	-24.011	11.0	8.5	26.57	34.80	10/1/2005	07:55	-46.330	-24.018	12.8	12.0	20.26	32.86
3/22/2005	11:18	-46.362	-23.986	7.6	5.0	27.51	33.82	10/1/2005	11:23	-46.325	-23.988	7.0	7.0	20.28	32.96
3/22/2005	14:34	-46.330	-24.018	12.8	10.0	26.78	34.25	12/13/2005	09:45	-46.376	-24.011	9.0	6.5	24.37	33.37
3/22/2005	12:00	-46.325	-23.988	6.7	3.5	26.82	34.38	12/13/2005	10:40	-46.362	-23.986	6.5	5.5	23.95	32.02
5/21/2005	09:50	-46.376	-24.011	10.7	8.0	25.5	35.01	12/13/2005	07:55	-46.330	-24.018	12.0	7.5	24.12	32.69
5/21/2005	10:25	-46.362	-23.986	7.6	5.0	25.4	34.72	12/13/2005	11:31	-46.325	-23.988	6.0	5.0	24.24	33.44

Bertioga channel

Date	Hour	Long.	Lat.	LD	SD	T*	S*	Date	Hour	Long.	Lat.	LD	SD	T*	S*
11/25/2004	08:33	-46.133	-23.857	11.9	8.0	24.78	30.89	5/22/2005	09:19	-46.133	-23.857	8.8	4.0	25.24	33.18
11/25/2004	09:03	-46.148	-23.860	3.0	2.0	24.84	30.80	5/22/2005	10:32	-46.148	-23.860	6.1	4.0	25.11	32.49
11/25/2004	09:30	-46.156	-23.866	5.0	4.0	24.82	30.45	5/22/2005	10:55	-46.156	-23.866	6.4	3.5	25.01	31.49
11/25/2004	11:35	-46.165	-23.878	6.7	5.5	24.84	30.91	5/22/2005	11:15	-46.165	-23.878	7.3	4.5	26.27	27.76
11/25/2004	12:10	-46.186	-23.891	4.3	3.0	24.90	29.19	5/22/2005	11:42	-46.186	-23.891	7.9	4.5	24.74	25.64
11/25/2004	12:34	-46.193	-23.902	7.0	6.0	25.40	27.36	5/22/2005	12:08	-46.193	-23.902	11.0	8.0	24.89	25.94
12/18/2004	07:05	-46.133	-23.857	12.5	12.0	26.07	34.16	6/25/2005	09:40	-46.133	-23.857	12.8	11.0	22.95	29.00
12/18/2004	08:45	-46.151	-23.859	5.2	4.0	26.10	33.99	6/25/2005	10:45	-46.148	-23.860	12.7	1.5	--	--
12/18/2004	09:25	-46.157	-23.867	5.5	5.0	26.11	33.82	6/25/2005	11:18	-46.156	-23.866	4.3	3.0	23.08	29.18
12/18/2004	09:55	-46.165	-23.878	6.4	6.0	26.08	32.92	6/25/2005	11:53	-46.165	-23.878	5.2	4.0	23.41	--
12/18/2004	13:05	-46.188	-23.892	6.7	4.0	26.08	31.44	6/25/2005	12:25	-46.186	-23.891	3.4	2.5	--	31.25
12/18/2004	13:36	-46.193	-23.902	7.0	4.0	26.32	26.48	6/25/2005	12:45	-46.193	-23.902	5.2	4.0	22.45	24.97
1/26/2005	09:15	-46.133	-23.857	12.8	10.0	25.69	21.56	7/24/2005	09:46	-46.133	-23.857	11.5	10.0	21.96	31.39
1/26/2005	10:29	-46.151	-23.859	5.8	4.0	25.56	21.17	7/24/2005	11:04	-46.148	-23.860	3.0	1.0	--	--
1/26/2005	12:00	-46.157	-23.867	5.8	4.0	25.69	21.56	7/24/2005	11:35	-46.156	-23.866	4.0	2.0	21.78	29.41
1/26/2005	12:14	-46.165	-23.878	7.3	5.0	25.76	19.90	7/24/2005	12:00	-46.165	-23.878	5.2	3.0	21.61	27.48
1/26/2005	12:42	-46.188	-23.892	5.5	4.0	25.78	18.99	7/24/2005	12:32	-46.186	-23.891	3.0	1.0	--	--
1/26/2005	13:01	-46.193	-23.902	6.4	5.0	25.78	18.99	7/24/2005	14:50	-46.193	-23.902	6.0	4.5	21.74	26.90
2/25/2005	08:22	-46.133	-23.857	13.8	8.5	27.29	30.76	8/21/2005	08:00	-46.133	-23.857	11.0	10.0	22.42	32.81
2/25/2005	09:37	-46.148	-23.860	5.0	3.0	27.39	28.15	8/21/2005	09:55	-46.148	-23.860	2.7	1.5	--	--
2/25/2005	10:02	-46.156	-23.866	4.6	3.5	27.58	27.02	8/21/2005	10:40	-46.156	-23.866	4.3	3.0	--	--
2/25/2005	10:26	-46.165	-23.878	5.8	4.0	27.42	28.08	8/21/2005	11:25	-46.165	-23.878	5.0	4.0	22.72	28.21
2/25/2005	12:40	-46.186	-23.891	7.3	5.0	27.63	26.37	8/21/2005	14:25	-46.186	-23.891	4.6	3.5	--	--
2/25/2005	13:10	-46.193	-23.902	10.0	7.0	27.63	26.37	8/21/2005	14:58	-46.193	-23.902	6.7	5.5	22.99	28.53
3/23/2005	08:05	-46.133	-23.857	11.3	8.0	27.52	31.18	10/2/2005	08:30	-46.133	-23.857	12.0	12.0	21.81	28.43
3/23/2005	--	-46.148	-23.860	12.2	--	27.62	30.42	10/2/2005	09:24	-46.148	-23.860	5.0	5.0	21.77	26.43
3/23/2005	09:35	-46.156	-23.866	6.4	3.0	27.52	30.33	10/2/2005	10:46	-46.156	-23.866	5.5	5.0	21.71	26.41
3/23/2005	09:59	-46.165	-23.878	5.8	2.5	27.52	29.36	10/2/2005	10:10	-46.165	-23.878	6.7	6.0	21.99	25.12
3/23/2005	10:28	-46.186	-23.891	6.4	4.0	27.89	27.15	10/2/2005	12:25	-46.186	-23.891	8.0	7.0	21.78	24.68
3/23/2005	10:57	-46.193	-23.902	5.8	5.0	28.05	26.32	10/2/2005	12:55	-46.193	-23.902	10.0	10.0	22.01	23.70
4/27/2005	09:03	-46.133	-23.857	13.4	12.0	24.07	18.42	12/14/2005	09:10	-46.133	-23.857	11.9	9.0	24.01	32.94
4/27/2005	10:36	-46.148	-23.860	6.4	6.4	--	--	12/14/2005	11:13	-46.148	-23.860	3.0	1.0	--	--
4/27/2005	10:59	-46.156	-23.866	5.8	5.0	24.74	21.61	12/14/2005	11:40	-46.156	-23.866	4.5	2.5	23.88	31.50
4/27/2005	11:22	-46.165	-23.878	6.7	6.7	24.33	20.06	12/14/2005	12:05	-46.165	-23.878	5.5	3.5	23.81	26.72
4/27/2005	11:49	-46.186	-23.891	6.1	6.4	24.21	19.76	12/14/2005	15:13	-46.186	-23.891	4.0	2.0	--	--
4/27/2005	12:10	-46.193	-23.902	7.9	9.5	24.15	19.44	12/14/2005	15:40	-46.193	-23.902	5.0	3.0	23.99	25.08

Port channel

Date	Hour	Long.	Lat.	LD	SD	T*	S*	Date	Hour	Long.	Lat.	LD	SD	T*	S*
11/24/2004	07:43	-46.300	-23.993	20.0	10.0	23.73	31.71	5/21/2005	12:22	-46.300	-23.993	21.0	18.0	25.39	34.30
11/24/2004	08:41	-46.303	-23.959	14.0	10.0	23.52	32.42	5/21/2005	13:42	-46.303	-23.959	14.0	10.0	25.32	34.34
12/17/2004	07:56	-46.299	-23.993	18.0	14.5	24.97	32.79	6/24/2005	13:50	-46.300	-23.993	16.0	14.0	23.45	32.62
12/17/2004	06:31	-46.303	-23.959	14.0	12.0	25.24	30.76	6/24/2005	14:59	-46.303	-23.959	13.0	12.0	23.41	32.49
1/25/2005	08:18	-46.299	-23.993	12.5	13.0	25.63	29.47	7/23/2005	13:30	-46.300	-23.993	15.0	13.5	21.83	34.31
1/25/2005	06:43	-46.303	-23.959	13.1	11.0	25.55	31.67	7/23/2005	15:09	-46.303	-23.959	13.0	11.5	21.81	32.97
2/24/2005	08:45	-46.300	-23.993	19.5	18.0	26.00	32.39	8/20/2005	14:04	-46.300	-23.993	15.0	14.0	22.09	33.54
2/24/2005	09:40	-46.303	-23.959	13.1	11.0	26.47	30.53	8/20/2005	15:50	-46.303	-23.959	13.0	15.0	22.01	33.41
3/22/2005	09:44	-46.300	-23.993	18.0	15.0	26.83	31.57	10/1/2005	13:10	-46.300	-23.993	14.0	14.0	20.72	31.64
3/22/2005	08:00	-46.303	-23.959	13.1	10.0	26.63	30.64	10/1/2005	14:40	-46.303	-23.959	14.0	14.0	20.83	30.95
4/26/2005	07:38	-46.300	-23.993	18.5	16.5	26.61	32.19	12/13/2005	13:00	-46.300	-23.993	14.0	12.0	24.03	31.45
4/26/2005	09:02	-46.303	-23.959	14.0	12.0	26.35	28.57	12/13/2005	14:26	-46.303	-23.959	13.0	11.0	23.84	30.53

Table 2. Data of sampling stations of catches carried out on the continental shelf adjacent to the Santos-São Vicente estuarine system, Brazil, in September 2005 and March 2006 (LD - Local Depth (m); SD - Sampler Depth (m); T – Temperature; S - Salinity obtained at 5 m depth).

Date	Hour	Long.	Lat.	LD	SD	T*	S*	Date	Hour	Long.	Lat.	LD	SD	T*	S*
9/21/2005	20:30	-45.560	-24.226	59	40	20.47	34.22	3/12/2006	06:45	-45.592	-23.820	15	10	26.82	33.92
9/22/2005	01:23	-45.707	-23.971	30	25	20.78	34.14	3/12/2006	09:22	-45.505	-23.966	28	20	27.04	34.21
9/22/2005	03:20	-45.790	-23.829	20	20	20.47	33.06	3/12/2006	11:30	-45.560	-24.226	41	35	27.11	34.84
9/22/2005	05:10	-45.991	-23.836	15	10	20.61	32.68	3/12/2006	13:55	-45.707	-23.971	50	45	27.18	34.95
9/22/2005	06:43	-46.039	-23.918	18	15	20.43	32.11	3/13/2006	14:57	-45.790	-23.829	53	45	26.81	34.99
9/22/2005	09:00	-45.899	-23.992	28	20	20.62	33.77	3/13/2006	17:50	-45.991	-23.836	43	35	27.35	35.06
9/22/2005	11:19	-45.820	-24.119	41	35	20.62	33.97	3/13/2006	21:50	-46.039	-23.918	29	24	27.31	34.17
9/22/2005	15:27	-45.701	-24.328	60	50	20.27	33.52	3/13/2006	23:25	-45.899	-23.992	15	10	27.54	33.90
9/22/2005	19:27	-45.880	-24.373	57	40	19.66	33.38	3/14/2006	01:23	-45.820	-24.119	15	10	27.55	33.94
9/22/2005	22:00	-45.965	-24.226	46	30	20.31	33.88	3/14/2006	03:29	-45.701	-24.328	30	25	26.76	34.78
9/23/2005	01:25	-46.053	-24.077	30	25	20.53	33.61	3/14/2006	05:50	-45.880	-24.373	45	35	26.76	35.18
9/23/2005	03:02	-46.101	-24.000	20	15	20.41	31.77	3/14/2006	08:26	-45.965	-24.226	55	50	26.08	34.91
9/23/2005	04:42	-46.178	-24.042	20	15	20.49	31.75	3/14/2006	11:02	-46.053	-24.077	55	50	26.12	35.00
9/23/2005	06:18	-46.257	-24.084	25	25	20.34	31.17	3/14/2006	13:30	-46.101	-24.000	40	35	26.74	35.12
9/23/2005	09:10	-46.209	-24.164	32	25	20.29	32.50	3/14/2006	16:20	-46.178	-24.042	33	28	27.08	34.79
9/23/2005	14:16	-46.120	-24.314	41	25	20.19	33.74	3/14/2006	19:05	-46.257	-24.084	16	11	28.06	33.95
9/23/2005	16:44	-46.034	-24.460	57	40	20.06	33.57	3/14/2006	20:27	-46.209	-24.164	20	15	27.66	33.98
9/23/2005	19:24	-46.188	-24.548	55	40	19.60	33.42	3/14/2006	21:48	-46.120	-24.314	24	15	27.51	34.40
9/23/2005	21:30	-46.274	-24.400	40	25	--	--	3/14/2006	23:05	-46.034	-24.460	31	25	27.53	34.21
9/23/2005	23:40	-46.362	-24.252	31	15	20.65	32.20	3/15/2006	01:38	-46.188	-24.548	42	35	25.71	35.12
9/24/2005	01:31	-46.357	-24.088	20	20	20.60	31.57	3/15/2006	04:15	-46.274	-24.400	57	50	25.96	34.96
9/24/2005	02:46	-46.458	-24.091	16	10	20.51	31.26	3/15/2006	08:15	-46.362	-24.252	57	52	25.17	35.22
9/24/2005	04:20	-46.617	-24.170	14	10	20.60	31.31	3/15/2006	10:28	-46.357	-24.088	46	40	26.14	35.12
9/24/2005	06:23	-46.517	-24.338	30	25	20.51	33.43	3/15/2006	13:10	-46.458	-24.091	28	20	27.44	34.45
9/24/2005	08:19	-46.430	-24.486	45	40	19.67	33.35	3/15/2006	15:20	-46.617	-24.170	21	15	27.47	34.51
9/24/2005	10:32	-46.342	-24.635	55	50	19.65	33.26	3/15/2006	16:38	-46.517	-24.338	21	15	27.56	34.38
9/24/2005	12:45	-46.497	-24.721	53	35	20.04	33.29	3/15/2006	17:58	-46.430	-24.486	18	10	27.60	34.39
9/24/2005	14:43	-46.584	-24.576	43	25	19.88	33.36	3/15/2006	19:02	-46.342	-24.635	15	10	27.35	34.56
9/24/2005	16:35	-46.670	-24.426	30	15	20.36	33.43	3/15/2006	20:50	-46.497	-24.721	27	22	26.49	35.03
9/24/2005	18:19	-46.768	-24.262	14	5	20.14	32.63	3/15/2006	22:45	-46.584	-24.576	40	30	26.34	34.98
9/24/2005	19:44	-46.914	-24.368	15	5	20.11	31.74	3/16/2006	05:10	-46.670	-24.426	60	55	25.78	34.99
9/24/2005	21:29	-46.825	-24.514	28	15	20.38	32.72	3/16/2006	07:25	-46.768	-24.262	60	55	26.07	34.88
9/24/2005	23:28	-46.740	-24.663	41	25	20.09	33.19	3/16/2006	10:20	-46.914	-24.368	31	25	25.62	35.03
9/25/2005	01:31	-46.653	-24.809	49	45	19.99	33.23	3/16/2006	13:20	-46.825	-24.514	19	15	27.23	34.65
9/20/2005	08:53	-45.592	-23.820	18	17	20.82	34.26	3/16/2006	15:00	-46.740	-24.663	18	14	27.58	34.41
9/20/2005	15:12	-45.505	-23.966	42	40	20.54	34.39	3/16/2006	17:00	-46.653	-24.809	43	38	26.75	34.67
								3/16/2006	19:20	-45.405	-24.105	54	50	26.68	34.80

According to Smith and Richardson (1977), ichthyoplankton was collected by oblique tows with a paired 60 cm bongo net with 333 mm and 505 mm mesh size. The net was towed in double oblique hauls at approximately 2 knots. Water volumes filtered were determined from flowmeters mounted at the centers of the nets. All samples were fixed in buffered 4% formaldehyde-seawater solution.

Temperature and salinity horizontal profiles, that were used to recognize the influence of the water masses, were taken at each station using CTD (Sea-Bird Electronics, Inc., mod. SBE19). These data were processed and provided by the Physical Oceanography team of IOUSP.

Larvae were examined under a stereomicroscope and the sciaenid identification was based on: Hildebrand and Cable (1934), Sinque (1980), Able and Fahay (1998), Chao (2002), Ditty et al. (2006), Fahay (2007) and Itagaki et al. (2007). Photographs taken with a digital camera connected to a stereomicroscope and the software ImageJ were used to measure the fish larvae.

Data Analysis

Analysis of variance (one-way ANOVA) was used to test the significant differences between the abiotic data of water temperature and water salinity, both at 5 m, which were calculated monthly and by estuarine area. We chose to study the abiotic data at 5 m depth to avoid any influence of the air temperature at the sea surface.

Guille (1970) was used as the basis for the calculation of the frequency of larval occurrence (FO). For the abundance estimative, the number of larvae collected at each station was transformed into the number of larvae per m^2 of sea surface, in accordance with the following equation: $Y = (D*X)/V$, where Y = number of larvae per square meter, D = maximum sampling depth (m), X = number of larvae collected, and V = volume of water filtered (m^3). The mean abundance was calculated for all the sampling stations, not only for the positive ones. Filtered volume was calculated as $V = a*n*c$, where a = area of net mouth (0.2827 m^2), n = number of rotations of the flowmeter and c = calibration factor of the flowmeter.

The influence of each abiotic variable on the Sciaenidae species was assessed by Canonic Correspondence Analysis (CCA) (LEGENDRE; LEGENDRE, 1998) and the distribution of the species in relation to the significant abiotic variables was determined by CANOCO. The Monte Carlo Permutation test was carried out to judge the significance of the selected variables. Rare species, those with less than 5 % of frequency of occurrence, were eliminated from the biotic matrix. The abiotic data, after a first analysis using a single matrix, were divided into three matrices: environmental (temperature and salinity, both at 5 m depth), spatial (north shelf, south shelf, bay, port, channel and local depth) and temporal (months sampled). In all analyses the biological data (number of individuals per m^2) were transformed by log (x+1), and low weight was given to rare species. The percentage of explanation of each abiotic variable was calculated in accordance with Borcard et al. (1992).

One-way analysis of similarity (ANOSIM) was performed to determine the significance of spatial trends in the structure of the Sciaenidae assemblage. The contribution of each species to the dissimilarity between different groups' species was estimated using analysis of similarity percentages (SIMPER). Both analyses were performed using the software package PRIMER 6 (Plymouth Routines Multivariate Ecological Research) (CLARKE, 1993). Rare taxa, with an occurrence frequency of less than 5%, were excluded from the analyses. Numerical density data expressed as number of individuals per m^2 were transformed using the log (x+1) function to enhance the contribution of the less abundant species. The analyses were undertaken on the basis of the Bray–Curtis similarity index (BRAY; CURTIS, 1957). R values approximating to 1 indicate great differences between the groups analyzed, while R values approximating to zero indicate low differences.

RESULTS

Hydrographic Conditions

Santos estuarine system. Water temperature at 5 m varied over the different estuarine areas (ANOVA, $p<0.05$) and over the sampling period (ANOVA, $p<0.05$), following a seasonal pattern. The lowest values occurred between July and October, and the highest ones from November 2004 to March 2005, and in December 2005 (Fig. 2). The maximum temperature was 28.05°C in March 2005 in the Channel and the minimum was 20.26°C in October 2005 in the Bay.

Water salinity at 5 m also varied over the different estuarine areas (ANOVA, $p<0.05$) and over the sampling period (ANOVA, $p<0.05$). Differently from water temperature, water salinity showed no seasonal pattern. Highest salinity values were measured in the Bay, followed by the Port and then by the Channel (Fig. 3). The maximum salinity was 35.72 in November 2004 in the Bay and the minimum was 18.42 in April 2005 in the Channel.

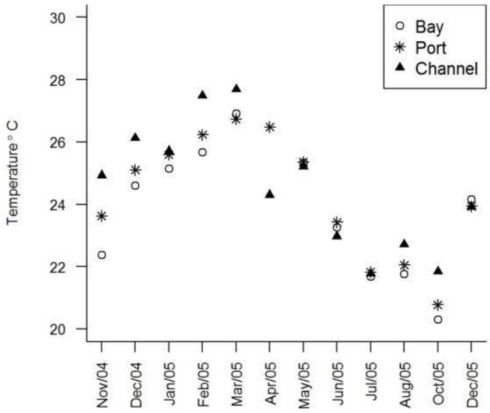

Fig. 2. Monthly variation of mean water temperature at 5 m depth measured in the Santos estuarine system from November 2004 to December 2005.

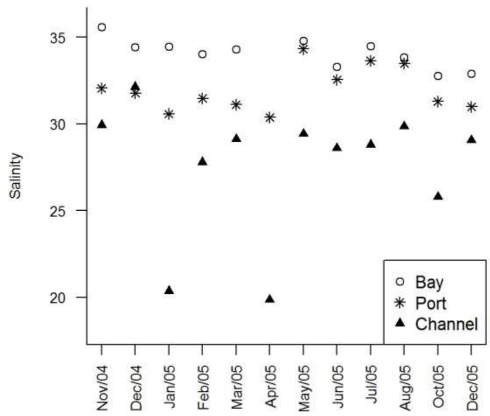

Fig. 3. Monthly variation of mean water salinity at 5 m depth measured in the Santos estuarine system from November 2004 to December 2005.

Adjacent continental shelf. In September 2005 the water temperature was almost homogeneous throughout the continental shelf (Fig. 4). At the surface a range from 19.59°C to 20.91°C was observed, averaging 20.38°C (sd = 0.37). At the deeper layer (25 m) the temperature range was slightly lower, from 19.00°C to 20.95°C (mean =19.95°C, sd = 0.51). In March 2006 the thermal structure was quite different from that observed in September 2005, with warmer surface seawater ranging from 25.17°C to 28.01°C (mean = 26.96°C, sd = 0.68), but lower temperatures were observed for the 25 m layer, with a minimum of 16.98°C and maximum of 23.60°C (mean = 20.34°C, sd = 1.79). This minimum temperature value, associated with salinity values around 35.7, indicates the presence of South Atlantic Central Water (SACW) in the deeper layer.

In September 2005 the surface water salinity ranged from 30.92 to 34.38 (mean = 32.91, sd = 1.03). At the 25 m layer higher salinity values were observed, ranging from 33.37 to 34.53 (mean = 33.82, sd = 0.33). In March 2006 the range of salinity was from 33.90 to 35.22 (mean = 34.63, sd = 0.41) at the surface, and from 35.63 to 36.10 (mean = 35.88, sd = 0.12) at the 25 m layer (Fig. 5).

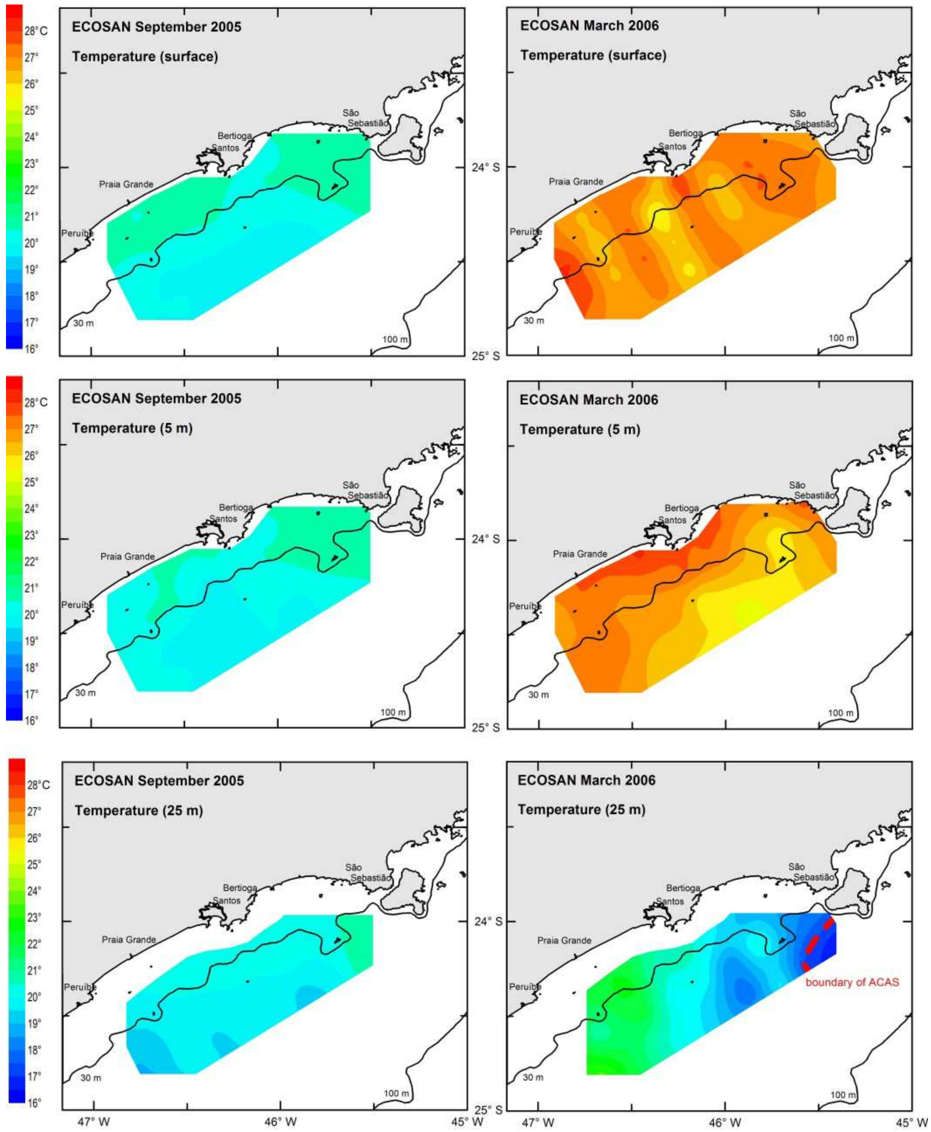

Fig. 3. Horizontal profiles of water temperature on the surface, at 5 m and at 25 m depth, measured in September 2005 and March 2006 between Peruíbe and the São Sebastião island, from the coast to the 50 m isobath. The dotted line indicates the boundary of the South Atlantic Central Water (SACW), according Castro et al. (2006).

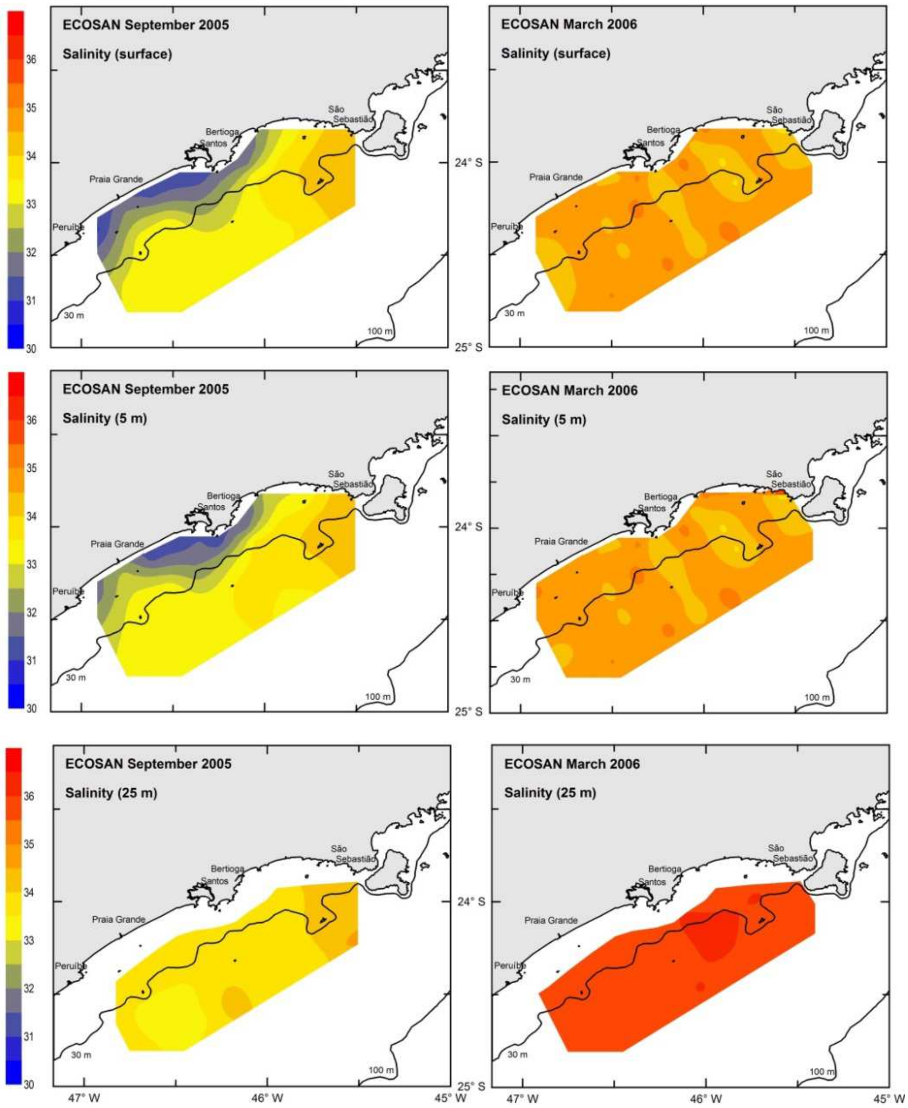

Fig. 4. Horizontal profiles of water salinity on the surface, at 5 m and at 25 m depth, measured in September 2005 and March 2006 between Peruíbe and the São Sebastião island, from the coast to the 50 m isobath.

Fish Larvae Distribution and Abundance

Santos estuarine system. A total of 11,811 fish larvae were collected in the estuarine system, and the sciaenids accounted for 12.71% of the total number. Most of the sciaenids were caught during November and December 2004. The mean abundance of sciaenid larvae ranged from 0.12 larvae.m^{-2} (sd = 0.11) in June 2005 to 4.28 larvae.m^{-2} (sd =1.99) in November 2004. The minimum FO was 50% in August 2005, and the maximum 100% in November 2004.

The following sciaenids were identified in the estuarine system: *Bairdiella ronchus*, *Cynoscion spp.*, *Isopisthus parvipinnis*, *Macrodon atricauda*, *Menticirrhus spp.*, *Micropogonias furnieri*, *Nebris microps* Cuvier, 1830, *Ophioscion punctatissimus* Meek & Hildebrand, 1925, *Paralonchurus brasiliensis* (Steindachner, 1875), *Stellifer rastrifer* and *Stellifer spp.* Of these, *S. rastrifer* was the most abundant (mean = 0.36 larvae.m^{-2}; sd = 0.35) and with higher FO (91.7%) (Table 3).

Adjacent continental shelf. A total of 17,572 fish larvae were collected on the continental shelf, 6.72% of them being sciaenids. Larvae of this family were widely distributed during both cruises, with FO greater than 85%, but were at their most abundant in March 2006. In this month the abundance varied from 0.27 larvae.m^{-2} to 35.73 larvae.m^{-2} (mean = 6.47 larvae.m^{-2}, sd = 8.36). In September 2005 the range was from 0.20 larvae.m^{-2} to 14.75 larvae.m^{-2} (mean= 2.37 larvae.m^{-2}, sd= 3.33).

Larvae of the following sciaenids were present in the shelf area: *Bairdiella ronchus, Ctenosciaena gracilicirrhus* (Metzelaar, 1919), *Cynoscion spp., Isopisthus parvipinnis, Macrodon atricauda, Menticirrhus spp., Nebris microps, Stellifer rastrifer* and *Stellifer spp*. *Cynoscion spp.* were the most abundant during both cruises, with a mean of 0.49 larvae.m^{-2} (sd = 1.81) and FO of 22.2% in September 2005, and 1.65 larvae.m^{-2} (sd = 3.44) and FO of 40.5% in March 2006. *Menticirrhus spp.* (mean= 0.12 larvae.m^{-2}; sd = 0.27) and *Stellifer spp.* (mean=0.40 larvae.m^{-2}; sd = 1.48) were the second in abundance, but respectively in September 2005 and in March 2006, both with the FO of approximately 22% (Table 4).

The Main Taxa Identified

*Bairdiella ronchus***.** In the estuarine system the highest abundance of *B. ronchus* occurred in November 2004 (0.10 larvae.m^{-2}), when larvae were widespread throughout the area (Bay, Port and Channel). In January and December 2005 they occurred only in the Bertioga channel and in February 2005 only in the Santos bay. The *B. ronchus* larvae found in the estuarine system accounted for only 0.93% of the sciaenids present there. On the adjacent continental shelf, the abundance of *B. ronchus* was highest in March 2006 (0.08 larvae.m^{-2}), their occurrence being restricted, however, to the southern part. In September 2005 their occurrence was restricted to only one station in the north. In the shelf area this species accounted for 1.10% of all the sciaenids. In the estuarine system the length frequency ranged from 2.29 mm to 4.28 mm, and on the shelf from 2.63 mm to 4.66 mm.

Table 3. Size range, abundance (larvae.m^{-2}), frequency of occurrence (%) and absolute number (N) of Sciaenidae larvae in the Santos estuarine system, Brazil, from November 2004 to December 2005.

Sciaenidae	Size		Abundance		FO	N
	Min	Max	Mean	SD		
Bairdiella ronchus	2.9	4.3	0.011	0.029	33.3	14
Isophistus parvipinnis	3.9	12.2	0.063	0.084	66.7	66
Macrodon atricauda	4.2	13.4	0.027	0.051	50.0	23
Micropogonias furnieri	3	13.7	0.111	0.146	83.3	123
Nebris microps	2.6	3.2	0.003	0.011	8.3	2
Ophioscion punctatissimus	4.5	4.5	0.001	0.005	8.3	1
Paralonchurus brasiliensis	4.5	7.3	0.004	0.007	25.0	3
Stellifer rastrifer	2.6	8.3	0.361	0.351	91.7	360
Cynoscion spp.	2.3	8.3	0.030	0.039	66.7	35
Menticirrhus spp.	2.4	6.6	0.057	0.089	66.7	67
Stellifer spp.	2.5	11.9	0.212	0.401	50.0	256
Non-identified						551
Total						15

Table 4. Size range, abundance (larvae.m^{-2}), frequency of occurrence (FO %) and absolute number (N) of Sciaenidae larvae on the continental shelf adjacent to the Santos-São Vicente estuarine system, Brazil, in September 2005 and March 2006.

Sciaenidae	September 2005						March 2006					
	Size		Abundance		FO	N	Size		Abundance		FO	N
	Min	Max	Mean	SD			Min	Max	Mean	SD		
Bairdiella ronchus	3.0	4.7	0.03	0.16	2.8	3	2.6	4.1	0.08	0.22	13.5	10
Ctenosciaena gracilicirrhus	-	-	0.01	0.04	2.8	1	-	-	-	-	-	-
Isophistus parvipinnis	3.8	5.0	0.02	0.09	5.6	2	-	-	-	-	-	-
Macrodon atricauda	3.6	4.0	0.01	0.05	5.6	2	-	-	-	-	-	-
Nebris microps	5.5	7.7	0.03	0.09	8.3	3	-	-	-	-	-	-
Stellifer rastrifer	-	-	-	-	-	-	2.6	6.2	0.08	0.48	2.7	13
Cynoscion spp.	2.2	4.2	0.49	1.81	22.2	56	1.8	6.1	1.65	3.44	40.5	224
Menticirrhus spp.	3.4	1.4	0.12	0.27	22.2	13	2.3	4.5	0.21	0.39	24.3	28
Stellifer spp.	3.5	9.8	0.06	0.20	8.3	10	2.2	6.9	0.40	1.48	21.6	51
Non-identified						187						573
Total						277						899

Isopisthus parvipinnis. The larvae of this species were almost exclusively estuarine, having their highest abundance in November 2004 (0.14 larvae.m^{-2}), January 2005 (0.24 larvae.m^{-2}) and March 2005 (0.19 larvae.m^{-2}). They occurred in the three estuarine areas (Bay, Port and Channel). Their body length ranged from 3.85 mm to 12.20 mm in the estuary. In the shelf area only three larvae were collected in September/2005, ranging from 5.07 mm to 7.24 mm.

Macrodon atricauda. Larvae of this species occurred in the estuarine system and on the adjacent continental shelf, but among the estuarine sites *M. atricauda* larvae were absent from the Bertioga channel. In the estuarine system the abundance was the highest in July 2005 (0.16 larvae.m^{-2}). In the shelf area this species was rare, with only two specimens collected in September 2005, representing a mean abundance of 0.01 larvae.m^{-2}. In the estuary the body length of *M. atricauda* ranged from 4.18 mm to 13.41 mm. The two larvae collected on the shelf were of 3.55 mm and 4.03 mm. *Micropogonias furnieri*. This species was absent from the adjacent continental shelf. On the other hand, its occurrence was observed throughout the estuarine system, mainly in October 2005 (mean abundance = 0.43 larvae.m^{-2}). In February 2005 this species was also abundant (mean = 0.39 larvae.m^{-2}), though it occurred only in the Bertioga channel. *M. furnieri* accounted for 8.19% of all the sciaenid larvae in the estuarine system. Body length ranged from 2.98 mm to 13.68 mm.

Stellifer rastrifer. This species occurred mostly in the estuarine system, the highest abundance (1.05 larvae.m^{-2}) being observed in January 2005. High abundance was also observed in November 2004, December 2004, and February 2005. *S. rastrifer* was one of most common sciaenids in the estuarine area, accounting for 23.99% of all the Sciaenidae larvae. No significant differences among the three estuarine areas were observed ($P<0.0001$). On the adjacent shelf area the larval *S. rastrifer* occurred only in March 2006, with low abundance (mean = 0.07 larvae.m^{-2}). In the estuary the length class ranged from 2.54 mm to 8.64 mm.

Cynoscion spp. This genus was present in the estuarine and the shelf areas. In the estuarine system *Cynoscion spp*. abundance was relatively low, the highest abundance occurring in November 2004 (0.12 larvae.m^{-2}). In the estuary the *Cynoscion spp.* represented 2.33% of sciaenids. On the adjacent continental shelf this genus was more common, with wider distribution and higher abundance observed in March 2006 (mean = 1.65 larvae.m^{-2}). In September 2005 the mean abundance was 0.49 larvae.m^{-2}. These larvae accounted for 23.70% of all the sciaenids in the shelf area.

Menticirrhus spp. This genus occurred in both estuarine and shelf areas. It contributed with a total of 4.46% of all the sciaenids in the estuary and 3.47% of those on the shelf. In the estuarine system the highest abundance was observed in November 2004 (mean = 0.31 larvae.m^{-2}) and in December 2004 (mean = 0.13 larvae.m^{-2}). On the adjacent continental shelf *Menticirrhus spp.* was more abundant (mean = 0.21 larvae.m-2) with wide distribution in March 2006.

Stellifer spp. In the estuarine system larvae of this genus were more abundant in November 2004 (1.92 larvae.m^{-2}) and December 2004 (1.49 larvae.m^{-2}). They were present in all the estuarine areas and contributed with 17.05% of the taxonomic composition of Sciaenidae. On the adjacent continental shelf, the genus presented its highest abundance and widest distribution in March 2006. It represented 5.16% of the sciaenids in the shelf area.

Abiotic influence on the Sciaenidae larvae

The abiotic variables explained 42.21 % of the variability of the biological data. The first two axes were responsible for 66.30% of biological data variation. Axis 1 was negatively correlated with local depth, South Shelf, North Shelf and salinity. Axis 2 was positively correlated with the months of July and October 2005 and negatively correlated with January 2005. The species-environment correlation presented high values on the first (0.89) and second (0.79) axes. The combined sum of canonical eigenvalues (1.675) equaled 42.2% of that for all the eigenvalues (3.968), showing the effect of an adequate building of an environmental relationship into the CCA model (Table 5). The canonic axes were significantly different by the Monte Carlo permutation test ($p= 0.0001$). Figure 6 represents the distribution of the species in relation to the significant abiotic variables.

Analyzing the environmental matrix, only salinity was significant by the Monte Carlos Permutation test, with an explanation of 7.18 % of the biological data variation (sum of all canonic eigenvalues = 0.28). *S. rastrifer* and *I. parvipinnis* were negatively correlated with salinity.

The temporal data were those with the highest influence on the biological data variation (percentage of explanation = 34.30%; sum of all canonic eigenvalues = 1.36). *I. parvipinnis* was positively correlated with January 2005. *M. furnieri* and *M. atricauda* were positively correlated with July and October 2005. *Cynoscion spp.* and *S. rastrifer* were more abundant during months of high temperature, during the rainy period.

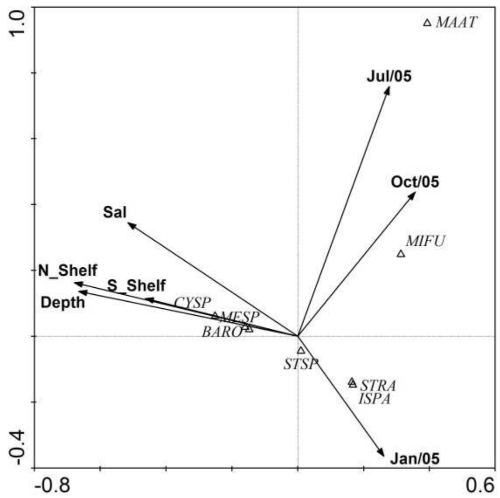

Fig. 6. Ordination diagram (biplot) from CCA including Sciaenidae species and significant environmental variables (represented by vectors) (BARO = *Bairdiella ronchus*; CYSP = *Cynoscion spp.*; ISPA = *Isopisthus parvipinnis;* MAAT = *Macrodon atricauda*; MESP = *Menticirrhus spp*; MIFU = *Micropogonias furnieri*; STRA = *Stellifer rastrifer*; STSP = *Stellifer spp*.).

Table 5. Summary of CCA performed on the abundance of eight most numerous Sciaenidae larval species, in the Santos estuarine system, from November 2004 to December 2005, and on the continental shelf adjacent to the Santos-São Vicente estuarine system, Brazil, in September 2005 and March 2006.

	Axes				
	1	2	3	4	
Summary statistics for ordination axes					
Eigenvalues	0.675	0.437	0.311	0.118	
Species-environment correlations	0.892	0.787	0.674	0.483	
Cumulative percentage variance:					
of species data	17.0	28.0	35.8	38.8	
of species-environment relation	40.3	66.3	84.9	91.9	
Sum of all eigenvalues					3.968
Sum of all canonical eigenvalues					

The spatial data explained 17.97 % of the biological data variation (sum of all canonic eigenvalues = 0.71), only the influence of south and north shelf and local depth being statistically significant. *B. ronchus, Menticirrhus spp*. and *Cynoscium* were positively correlated with the south and north shelf.

One-way analysis of similarity (ANOSIM) showed significant differences between the continental shelf and the estuarine areas. Within the estuarine areas, only Bay and Channel showed significant differences. The differences were more evident between the more distant regions, as exemplified by those between Shelf and Channel (R=0.44) (Table 6). These results showed a gradual spatial variation of the Sciaenid larvae between the continental shelf and the inner estuarine area.

Table 6. Similarity analysis of Sciaenidae larval groups between the different sampling areas: Shelf, Bay, Port and Channel.

	R	p
Shelf - Bay	0.273	0.001
Shelf - Port	0.402	0.001
Shelf - Channel	0.440	0.001
Bay - Port	-0.006	0.526
Bay - Channel	0.130	0.005
Port - Channel	0.113	6.900

According to SIMPER analysis, the species that most contributed to the formation of the Shelf group were: *Cynoscion spp.* (64.44%), *Menticirrhus spp.* (20.15%) and *Stellifer spp.* (10.33%); to the Bay group: *S. rastrifer* (43.71%), *Stellifer spp.* (17.97%), *M. funrieri* (10.54%), *Menticirrhus spp.* (10.29%) and *I. parvipinnis* (7.96%), and to the Port group: *S. rastrifer* (72.61%), *M. atricauda* (10.78%) and *Menticirrhus spp.* (7.53%). Finally, the Channel group consisted mainly of: *S. rastrifer* (78.09%), *Stellifer spp.* (10.16%) and *M. furnieri* (6.03%).

Discussion

Although Sciaenidae do not constitute a dominant family, they can be recognized as an important component of the ichthyoplankton in the present study area. As indicated by our results, the sciaenid accounted for 12% and 15% of total fish larvae in the estuary and on the adjacent continental shelf, respectively. Some similar results have been observed in various estuarine and coastal areas around the world. For instance, Rakocinski et al. (1996), by analyzing the ichthyoplankton assemblage structure in Mississippi Sound, described the sciaenids as being among the seven major groups. According to Katsuragawa and Dias (1997), in a region very close to that of the present study, the inner shelf of São Sebastião, the Sciaenidae constituted the 8th family among all the larvae identified, but the second among the demersal group.

The literature indicates that the sciaenids, mainly during their early life stages, prefer protected environments, such as those provided by mangrove swamps, estuaries and bays (CHAO, 1978). The notable presence of Sciaenidae in estuarine and coastal ecosystems has long been known, mainly as a result of studies of adult specimens. Several studies may be cited, especially relating to the southeastern Brazilian coast, e.g. Chaves and Corrêa (1998), Chaves and Bouchereau (2000), Pessanha et al. (2000), Araújo et al. (2002) and Spach et al. (2004). Concerning the area investigated by the present study, Paiva Filho and Schmiegelow (1986) reported the Sciaenidae as a family of higher biomass and number of specimens, according to their estimates based on their bottom trawling method in the Santos bay.

A feature of the sciaenids collected in the present study was the large number of small larvae, which caused us some difficulty in identifying the specific levels. However, nine species (*Bairdiella ronchus, Ctenosciaena gracilicirrhus, Isopisthus parvipinnis, Macrodon atricauda, Micropogonias furnieri, Nebris microps, Ophioscion punctatissimus, Paralonchurus brasiliensis* and *Stellifer rastrifer*) and three genera (*Cynoscion spp*., *Menticirrhus spp*. and *Stellifer spp*.) were classified. As compared with the São Sebastião region (Katsuragawa; Dias, 1997), it may be observed that the taxonomic composition of the sciaenids in the two areas differed by virtue of the presence of five species (*Cynoscion leiarchus*, *Larimus breviceps*, *Macrodon ancylodon*, *Menticirrhus americanus* and *P. brasiliensis*) and the absence of *M. atricauda* in São Sebastião. Unfortunately, due to their small size, the *Menticirrhus* and *Cynoscion* genera of the present study could not be refined to species level, but probably *M. americanus*, the main species and widely distributed in São Sebastião (KATSURAGAWA; DIAS, 1997), was also present in Santos. The species *S. rastrifer*, *I. parvipinnis,* and *M. atricauda* were also reported with great frequency and abundance among the adult specimens in the Santos region (GIANNINI; PAIVA FILHO, 1990; SCHMIDT; DIAS, 2012).

The considerable presence of early larval stages suggests an effective use of the Santos estuarine system as a spawning or nursery ground by sciaenid species. On the other hand, the shelf area was in general poor in terms of abundance, and among the species identified, the larval *M. furnieri* was absent. Our results concerning the role of the estuarine system are coherent with the presence of adult sciaenids there, e.g. Chaves (1995) reported that the reproduction of *B. ronchus* occurs inside the Guaratuba bay and that, thereafter, the adults disperse in the coastal area. *M. furnieri* is known as a species highly dependent on semi-enclosed systems such as bays and estuaries (GIANNINI; PAIVA FILHO, 1990; VIEIRA; CASTELLO, 1997; COSTA; ARAÚJO, 2003), and juveniles and pre-recruits are not present in the shelf area (CASTELLO, 1986; VAZZOLER, 1991). According to Vieira and Castello (1997), living the first year of life inside the Patos lagoon may help the early stages to avoid predation.

Many authors refer to the estuaries as nursery ground for fish (*e.g.* GODEFROID et al., 1999; COSTA; ARAÚJO, 2003). Lowe-McConnell (1987) included the sciaenids in a group of migrant marine fishes which breed in the sea and whose young enter the estuaries to feed and shelter until their gonads start to mature. Able and Fahay (1998), in a study on the sciaenid species found in the Middle Atlantic Bight, reported that spawning areas are diversified, occurring close to the coast for species such as *Cynoscion regalis*, within harbors, estuaries and sounds for *Bairdiella chrysoura*, and on the continental shelf for *Leiostomus xanthurus* and *Micropogonias undulatus*, all of them, however, being found in estuaries during their first year of life. The sciaenids in the study area seem to follow these trends, with spawning occurring throughout the shelf area, as evidenced by our results for many species, whereas the higher abundance of larvae in the estuarine system may be a clue to spawning activity within this area. At least four species (*Stellifer brasiliensis*, *S. rastrifer*, *I. parvapinnis* and *P. brasiliensis*) are known to complete their reproductive cycle inside the Santos bay.

Temporal change, the abiotic variable that presented the highest percentage of explanation of the occurrence and abundance of sciaenid larvae, is also reflected in their patterns of reproduction and intensity of spawning. Chaves (1995) found that *B. ronchus* reproduces during spring and summer, the period of larval peak abundance for this species in the present study area. Based on the reproductive biology studies of *S. rastrifer* from Guanabara bay, Chaves and Vendel (1997) observed more intense reproductive activity during the winter and especially in spring. In the present study the peak of mean abundance of larval *S. rastrifer* was observed to occur in January, though this species was well represented throughout the year. This result corroborates the study of Sinque (1980), which found large numbers of *S. rastrifer* larvae throughout the year in the Cananéia-Iguape estuarine system. This larval occurrence and abundance pattern also matches the continuous spawning behavior of adults observed by Schmidt (2011) evidenced by the presence of spawning females in samples caught in at least eight months of the year. Another species with variable abundance along the year was *M. furnieri*, with two peaks (February and October 2005). This result is coherent with the study on reproductive biology conducted by Isaac-Nahum and Vazzoler (1987) who reported a long spawning period during the four seasons.

Historically the Santos estuarine system has been affected by anthropic activities. However, the three estuarine areas investigated in this study present distinct features concerning the source and relative level of the impacts caused. The Santos port area is supposed to have been the most heavily impacted by the several activities related to industry, port and urbanization, and one of the thoughts entertained at the beginning of the ECOSAN project was that, of the areas involved, the Bertioga channel would be the least severely impacted. Our results suggest that the differences among areas have not affected the abundance of sciaenid larvae, as indicated by the ANOSIM.

It is not easy to identify the main environmental factors that influence the distribution and abundance of fish (larvae or adults) in an estuarine system, because in estuaries the lives of organisms are controlled by the interaction of many different abiotic and biotic factors (ALLEN, 1982; LOWE-MCCONNELL, 1987; SPACH et al., 2004). Estuaries are characterized by varying salinity, temperature, turbidity, muddy bottoms, strong currents and freshwater flowing out over the denser more saline water (LOWE-MCCONNELL, 1987). The biotic factors include availability of prey, competitors and predators (ALLEN, 1982). In the present study it has not been possible to evaluate the influence of biotic factors, but the CCA analysis indicated that the abiotic variables measured in the present study showed a high percentage of explanation of the variability of larval sciaenids (42.21 %). This larval variation was explained mainly in terms of the different months sampled (temporal influence), local depth, the south and the north part of the shelf area (spatial influence) and salinity. In this case, the variation in the abundance of larvae in the estuarine system seems, in general, to follow the seasonal patterns observed in the marine coastal waters along the southeastern Brazil coast, with higher abundance during spring and summer.

Although the influence of the temperature on the sciaenid larvae species variation was not significant in this study, it is known that temperature is one of the most important physical properties of the marine environment as it exerts an influence on many physical, chemical, geochemical and biological events (LALLI; PARSONS, 1995). We believe that temperature has been best represented by the temporal data analysis.

In the Santos estuarine system the average temperature is always higher than 20°C, the lowest average being 22.60°C, in the winter, and the highest average 26.09°C, in summer. The large difference between the mean temperatures during spring 2004 (25.28°C) and spring 2005 (22.60°C) may suggest an interannual oscillation in the thermic structure of this area. However, the seasonal range of temperature (from the minimum of 20.77°C to the maximum of 28.50°C) in the present study is far smaller than that observed in other areas, e.g. 9.0°C - 33.5°C in the Mississippi Sound (Rakocinski et al., 1996) and 0°C – 28°C in the Chesapeake Bay (Able; Fahay, 1998). The relatively small variation in temperature perhaps contributed to the all-year-round patterns of distribution and abundance of larval sciaenids in the Santos estuarine system with a tendency to greater abundance in the warmer months.

In the shelf area the thermal dynamics were very different, varying from almost homogeneous and colder in September 2005 (19.00°C – 20.95°C) to a stratified March 2006 scenario with warm water (25.17°C – 28.01°C) at the surface but cold water (minimum of 16.98°C) at the 25 m layer, suggesting the presence of SACW. However, according to the ECOSAN reports (Pires-Vanin et al., 2008), this intrusion of SACW did not reach the euphotic zone, and the new primary production was not significant. Pires-Vanin et al. (2008) concluded that on the shelf off Santos the contribution of SACW to the fertilization of the surface water is not as effective as it is off the Ubatuba and São Sebastião coast, perhaps due to the greater width of the continental shelf in the study region. In this case, the role of the estuarine system in providing organic matter for, at least, the neighboring coast must be of great importance in promoting primary production.

The results of the present study show that the abundance in the shelf area was considerably higher in March 2006 both for larval sciaenids and for total fish larvae collected, indicating a seasonal variation with an increase during the warm season, similar to that observed on other parts of the southeastern coast by several authors, e.g. Matsuura et al. (1992), Katsuragawa et al. (1993) and Lopes et al. (2006).

ACKNOWLEDGEMENTS

We thank FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo) for providing the financial support for the ECOSAN project. We are grateful to the captains and crews of R.V. “Prof. W. Besnard” and the boats for their cooperation and assistance in the sampling described in this study. We would also thank Drs. Luiz Bruner de Miranda and

Belmiro Mendes de Castro for providing the CTD data used in this project.

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(Manuscript received 29 July 2013; revised 13 March 2014; accepted 20 March 2014)